Transient Simulation for Signaling Evaluation

Charles Moore
with help from: Mary Mandich, Jeff Sinsky, and Richard Mellitz

September 9, 2004

Agilent Technologies

Overview

1. Goal
2. Proposal
3. Discussion
4. Remaining Tasks

Goal

To present a common simulation method to allow comparison of signaling methods that is:

- Complete
- General
- Reasonably Accurate
- Fair
- **Can be supported by all or most of the ad-hoc**

Goal (cont.)

"Complete" is defined as:

1. Allows someone to do a simulation to find out if a given signaling method works:
   - Over any one of a set of prescribed channels.
   - With ad-hoc committee prescribed conditions and impairments.
   - With no need for any other inputs, other than a receiver model.
2. Complete by September Interim, with some later tweaking of conditions and impairments by the ad-hoc or the Interim group.

Goal (cont.)

“General” is defined as:

Reasonable to infer from the simulations that not just the cases simulated work at a certain level — but that any system which meets a reasonable set of specifications works to at least the same level.

Goal (cont.)

"Reasonably Accurate" is defined as:

Accurate enough to distinguish well be between systems which work with significant margin and those which fail. No simulation will be good enough to distinguish between systems which barely pass and those which barely fail.

If the difference between the margin available for different signaling methods is small, the choice will have to be made on the basis of other considerations.

Goal (cont.)

“Fair” is defined as:

Realistic enough to include most or all effects which determine whether a system will work and does not exclude or over emphasize any effects which are more important to one or another signaling method.

Flexible enough to allow the proponents of each signaling method to "give it their best shot.“

Transparent enough so that everyone can be satisfied that it is fair.

Proposal

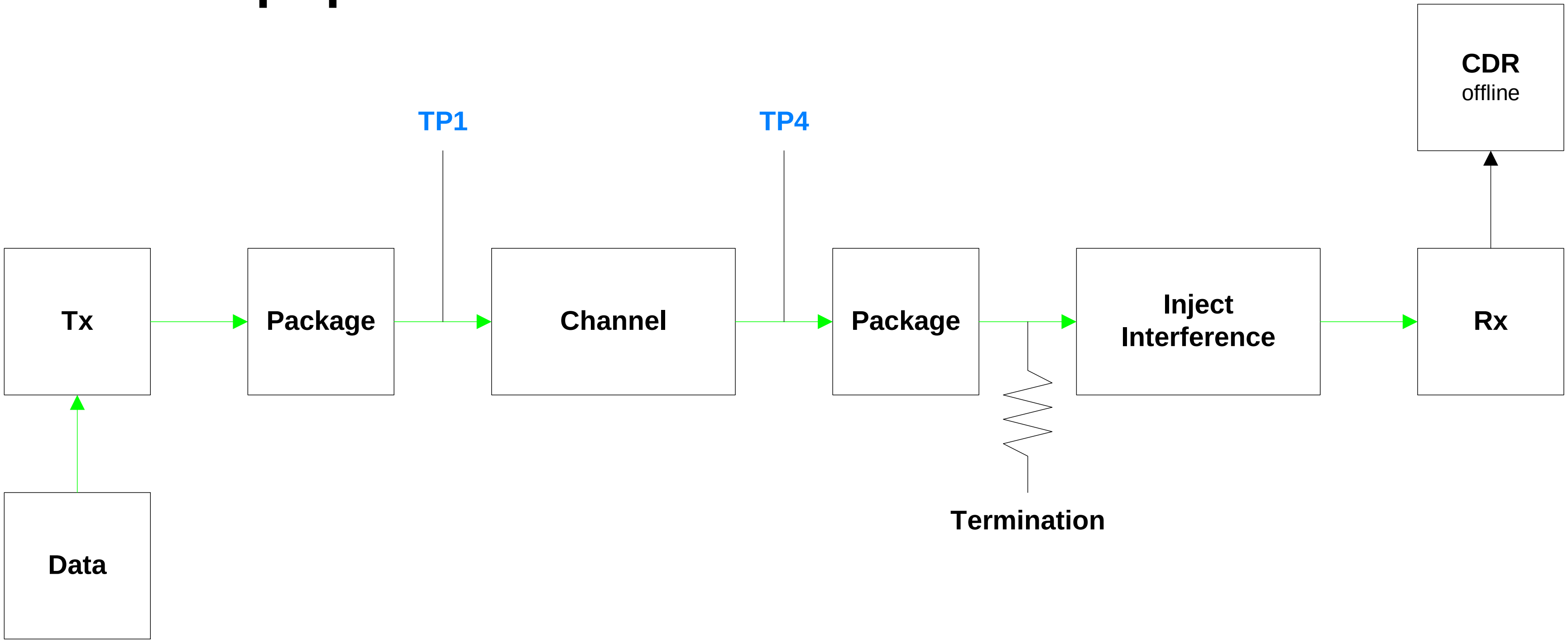
Simulate with hspice transient simulation using a set of agreed upon simulation files and conditions and a signaling method dependent receiver and some parameters defined by the simulator.

Measure the quality of the link by the amount of interference above a specified value at which data can still be transmitted error free.

Proposal (cont.)

I have, or will soon have, uploaded to the ad-hoc committee web site a zip archive containing a "starter set" of simulation files. There are still some holes in the set and there will be future upgrades.

Here is the proposed link to simulate:



Proposal (cont.)

Tx and Data:

Tx is a transmitter with a 3 tap equalizer with internal termination. It includes fast and slow sinusoidal jitter, to simulate duty cycle errors and other sources of RJ and DJ.

The Data is PRBS:

	NRZ Duo-Binary **PAM4 MSB**	**PAM4 LSB**
Short Simulation	7 Bit 127 symbols long	6 Bit 63 symbols long
Long Simulation	16 Bit 65535 symbols long	15 Bit 32767 symbols long

Proposal (cont.)

Package:

Package model thanks to Richard Mellitz — he has provided 2 models. For further information please see Richard.

Proposal (cont.)

Channel:

Channel model will use Touchstone (s4p) models provided from various sources.

Proposal (cont.)

Receiver Termination:

Receiver termination is outside the Rx to allow more accurate interference injection.

Proposal (cont.)

Inject Interference:

Sinusoidal interference will be added, see discussion later.

Proposal (cont.)

Receiver:

Rx models need to be provided by proponents of the various signaling methods. If they contain proprietary information, they may be made available to others in encrypted form.

This block is intended to contain only the equalizer and not the slicer or CDR unless they are fundamental parts of the receiver.

Proposal (cont.)

The slicer and CDR function is done offline by a common program written in C (by Charles).

The program includes an ideal slicer, a simple bang-bang PLL-DLL for clock recovery, and a self seeding shift register with feedback for error detection.

Discussion

Acceleration:

It is impossible to do a long enough hspice simulation to demonstrate a bit error rate of 1E-12 let alone the higher values we are being asked for. To have any useful meaning failure rates must be accelerated greatly. I propose to accelerate errors by adding an interfering signal. This signal is the sum of two terms:

1. Cross Talk. In effect, this puts a rare, worst case, cross talk signal on to the receiver all the time.

2. Noise. The idea is to increase the interfering signal by an amount corresponding to a noise spike of probability 1E-NN where NN is somewhere in the range 12-17 and the Rx input referred noise is still TBD.

Discussion (cont.)

Cross Talk:

Worst case cross talk can be found by the method I spelled out at the July meeting. This method explicitly uses a one symbol time pulse and gives different results between NRZ and PAM4, which will have to be carried into the simulation.

I plan to take the sum of NEXT terms for each channel available and choose the worst value from a compliant channel as the standard NEXT. I am less certain how to handle FEXT, and welcome assistance. In any case NEXT is added to FEXT to get the total cross talk which is used in defining the interference.

I plan on using worst case NEXT because I see no reason to believe that NEXT is correlated to channel loss. In the interests of generality I want to associate worst case NEXT with worst case channel loss even if the data set we get does not have them associated.

I expect FEXT to have at least some correlation with channel loss so we may want to leave the association of FEXT to channel loss.

Discussion (cont.)

Interference:

I wish to use a sine wave at near the Nyquist rate for the interfering signal because cross talk tends to be biased toward high frequencies and the Nyquist frequency is most likely to be amplified by the Rx equalizer.

It may turn out best to use half Nyquist frequencies for duo-binary.

Discussion (cont.)

Data:

I am using PRBS data which should have similar statistical characteristics to scrambled data, which we all seem to assume.

There are short data patterns which should simulate quickly and allow the simulator to find worst case terminations, and packages models, optimum receiver and transmitter settings, and maximum interference for no errors.

I will have longer data patterns for final simulations, once the proper settings have been found.

Discussion (cont.)

CDR:

The CDR may be able to provide remaining jitter tolerance values as well as error rate.

Remaining Tasks

Not an exhaustive list:

0. Find out if ad-hoc committee wants to continue with this idea
1. Generate CDR program present to ad-hoc
2. Choose agreed upon values for lots of things including:
   - Amount of jitter.
   - Fraction of jitter which is fast.
   - Amount of termination error.
   - Package model.
   - Minimum interference tolerance.
3. Clean up simulation files.
4. Fix problems uncovered by group.